NASA Innovative Advanced Concepts

Stellar Echo Imaging of Exoplanets

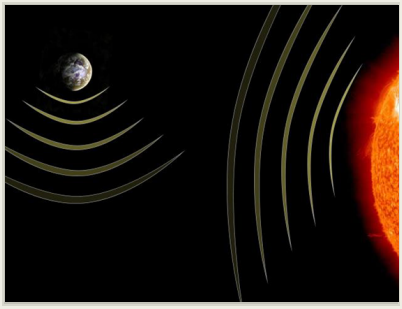
Completed Technology Project (2016 - 2017)

Project Introduction

All stars exhibit intensity fluctuations over several time scales, from nanoseconds to days; these intensity fluctuations echo off planetary bodies in the star system and provide an opportunity to detect and possibly image exoplanets using modern computational imaging techniques. A mission utilizing stellar echo detectors could provide continent-level imaging of exoplanets more readily than interferometric techniques, as high temporal resolution detection is less technically challenging and more cost effective than multikilometer-baseline fringe-tracking, particularly in a photon-starved regime. The concept is also viable for survey missions for detecting exoplanets at more diverse orbital inclinations than is possible with transit or radial velocity techniques.##Under a Phase I NIAC program, we evaluated the feasibility of the stellar echo technique and, while several practical constraints have been identified, we have not identified any fundamental limitations. We determined that the foundational technology already exists and has high TRL in space missions. Furthermore, the measurements required to demonstrate the feasibility of stellar echo detection are complementary to asteroseismology measurements, so a demonstration mission would provide high-value scientific information to other active astrophysics programs.##Under the Phase II program, we will continue to advance the theoretical understanding of stellar echo imaging, improve on the computational methods developed in Phase I, evaluate specific hardware implementations, and ultimately produce a roadmap for the demonstration of stellar echo detection and imaging of exoplanets.

Anticipated Benefits

Under the Phase II program, we will continue to advance the theoretical understanding of stellar echo imaging, improve on the computational methods developed in Phase I, evaluate specific hardware implementations, and ultimately produce a roadmap for the demonstration of stellar echo detection and imaging of exoplanets.



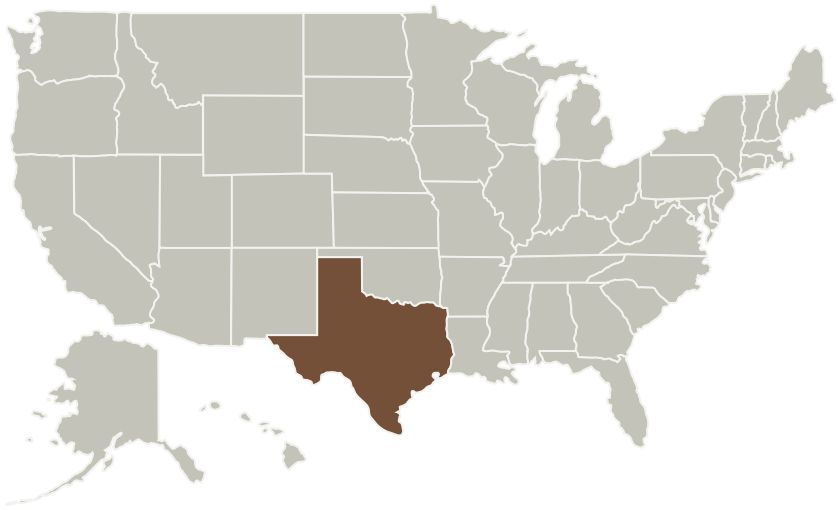
Graphic depiction of the Stellar Echo Imaging of Exoplanets using an interferometric technique.

Table of Contents

Stellar Echo Imaging of Exoplanets

Completed Technology Project (2016 - 2017)

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Nanohmics, Inc.	Lead Organization	Industry	Austin, Texas

Primary U.S. Work Locations
Texas

Project Transitions

July 2016: Project Start

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

Nanohmics, Inc.

Responsible Program:

NASA Innovative Advanced Concepts

Project Management

Program Director:

Jason E Derleth

Program Manager:

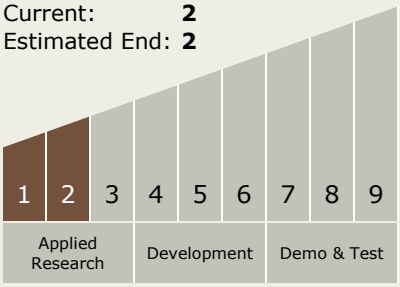
Eric A Eberly

Principal Investigator:

Chris Mann

Technology Maturity (TRL)

Start: **1**
Current: **2**
Estimated End: **2**



Stellar Echo Imaging of Exoplanets

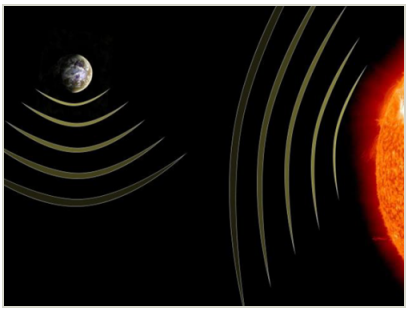
Completed Technology Project (2016 - 2017)

June 2017: Closed out

Closeout Summary: All stars exhibit intensity fluctuations over several timescales, from nanoseconds to years. These intensity fluctuations echo off bodies and structures in the star system. We posit that it is possible to take advantage of these echoes to detect, and possibly image, Earth-scale exoplanets. Unlike direct imaging techniques, temporal measurements do not require fringe tracking, maintaining an optically-perfect baseline, or utilizing ultra-contrast coronagraphs. Unlike transit or radial velocity techniques, stellar echo detection is not constrained to any specific orbital inclination. Current results suggest that existing and emerging technology can already enable stellar echo techniques at flare stars, such as Proxima Centauri, including detection, spectroscopic interrogation, and possibly even continent-level imaging of exoplanets in a variety of orbits. Detection of Earth-like planets around Sun-like stars appears to be extremely challenging, but cannot be fully quantified without additional data on micro- and millisecond-scale intensity fluctuations of the Sun. We consider survey missions in the mold of Kepler and place preliminary constraints on the feasibility of producing 3D tomographic maps of other structures in star systems, such as accretion disks. In this report we discuss the theory, limitations, models, and future opportunities for stellar echo imaging.

Closeout Link: https://www.nasa.gov/feature/stellar-echo-imaging-of-exoplanets

Images



Project Image
Graphic depiction of the Stellar Echo Imaging of Exoplanets using an interferometric technique.
(https://techport.nasa.gov/image/102250)

Links

NASA.gov Feature Article
(https://www.nasa.gov/feature/stellar-echo-imaging-of-exoplanets)

Technology Areas

Primary:

- TX08 Sensors and Instruments
  - TX08.1 Remote Sensing Instruments/Sensors
    - TX08.1.1 Detectors and Focal Planes

Target Destination

Outside the Solar System

Project Website:

https://www.nasa.gov/directorates/spacetech/niac/index.html#.VQb6I0jJzyE